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Variations in Infant Feeding Practice Are Associated with Body Composition in Childhood: A Prospective Cohort Study

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Context: Most studies of infant diet and later body composition focus on milk feeding; few consider the influence of variations in the weaning diet.

Objective: Our objective was to examine how variations in milk feeding and the weaning diet relate to body composition at 4 yr.

Study Population: A total of 536 children participating in a prospective birth cohort study.

Design: Diet was assessed at 6 and 12 months of age. Compliance with weaning guidance was defined by the infant's score for a principal component analysis-defined dietary pattern (infant guidelines) at 12 months. Infants with high infant guidelines scores had diets characterized by high consumption of fruit, vegetables, and home-prepared foods. Body composition was assessed at 4 yr by dual x-ray absorptiometry.

Results: Longer duration of breastfeeding was associated with lower fat mass at 4 yr [4.5 kg, 95% confidence interval (CI) of 4.3–4.7 kg, in children breastfed for 12 months or more, compared with 5.0 (95% CI 4.7–5.3) kg in children never breastfed ($P = 0.002$)] but was not related to body mass index. Children with high infant guidelines scores had a higher lean mass [12.6 (95% CI 12.3–12.9) kg in children in the top quarter of the distribution, compared with 12.0 (95% CI 11.7–12.4) kg in children in the bottom quarter ($P = 0.001$)]. These associations were independent and were little changed by adjustment for confounding factors.

Conclusions: These data suggest that variations in both milk feeding and in the weaning diet are linked to differences in growth and development, and they have independent influences on body composition in early childhood. (*J Clin Endocrinol Metab* 94: 2799–2805, 2009)

The dramatic rise in the prevalence of obesity in children has focused attention on critical periods in the life course when risk of obesity is increased and when public health interventions may be effective in preventing excess weight gain (1). Infancy is a period of rapid growth and gain in adiposity (2), and a number of studies have examined the link between milk feeding in infancy and risk of obesity at later ages (3–5).

There is some evidence that longer duration of breastfeeding is associated with a lower body mass index (BMI) (6), although the effects on mean BMI are generally small, and this association is not evident in all studies (7, 8). Evidence of a protective effect of breastfeeding is more consistent when considering overweight (3–5, 9) and an inverse dose-response relationship with longer duration of breastfeeding described in some studies (4, 5) sug-

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Abbreviations: BMI, Body mass index; DXA, dual x-ray absorptiometry; FFQ, food frequency questionnaire; IQR, interquartile range; PCA, principal component analysis; SWS, Southampton Women's Survey.

gests that it could play a significant role in the prevention of later obesity. However, many of these studies are limited by their ability to consider the role of confounding influences (7) because the choice to breastfeed may be associated with less obesogenic family characteristics such as higher levels of education and lower prevalence of obesity in the parents (10, 11). In studies that have taken account of the effects of such confounding factors, the inverse associations described between breastfeeding and later obesity are markedly reduced (3).

BMI is a surrogate marker for adiposity, and only a few studies have examined relationships between direct measures of adiposity in childhood, determined by dual x-ray absorptiometry (DXA), and milk feeding in infancy (10, 12–14). Of three small studies, two found inverse but nonsignificant associations between duration of breastfeeding and adiposity (12, 13), whereas in the third, an inverse association was described among girls but not boys (14). In a larger study of 4325 children aged 9–10 yr (10), an inverse association between duration of breastfeeding and fat mass was found. This was attenuated, but not removed, by adjustment for confounding factors. Although the authors concluded that confounding may explain inverse associations between breastfeeding and adiposity in childhood, they also suggested that breastfeeding could have protective effects if maintained for more than 6 months.

A confounding influence that is rarely considered in relation to the association between breastfeeding and later obesity is the nature of the weaning diet (13). Factors that relate to the duration of breastfeeding, such as maternal education, also influence the age when solid foods are introduced (15) and the types of solid foods fed during weaning (15–17). Both milk feeding and variations in the weaning diet should therefore be considered when examining the influence of infant diet on later body composition (13).

We describe the associations between infant feeding and body composition, determined using DXA, in a group of 536 children studied at the age of 4 yr, who were born to women in a prospective birth cohort study (18). Using data collected when the children were aged 6 and 12 months, we consider relationships between the duration of breastfeeding and compliance with weaning guidance, with fat mass and lean mass at 4 yr of age.

Subjects and Methods

Southampton Women's Survey

Between 1998 and 2002, all nonpregnant women in Southampton, UK, aged 20–34 yr, who were registered with a general practitioner were invited to take part in a large prospective study, the Southampton Women's Survey (SWS). A total of 12,583 women were recruited to the study (18). Trained research nurses visited each woman at home, when detailed information about health and lifestyle was collected, and anthropometric measurements were taken. Women in the SWS who became pregnant were studied throughout their pregnancy; their children are being followed up in infancy and in early childhood.

Approval for all components of the SWS was given by Southampton and South West Hampshire Local Research Ethics Committee.

Maternal and infant data

Details of mother's age and educational attainment were obtained at the prepregnant interview, and height and weight were measured. Educational attainment was defined in six groups according to the woman's highest academic qualification; social class was defined according to the woman's most recent occupation. Mother's smoking status in late pregnancy was ascertained at interview at around 34 wk gestation.

The infants were visited within 2 wk of their 6-month birthday and within a period 2 wk before and 3 wk after their 12-month birthday. Details of the milk feeding history over the preceding 6 months were recorded for all infants at the 6- and 12-month visits. Duration of breastfeeding was defined according to the date of the last breastfeed. Diet was assessed using a food frequency questionnaire (FFQ) that was administered by trained research nurses to record the average frequency of consumption of the listed foods over the month preceding the home visit (16). The age at which solid foods were introduced into the infant's diet was recorded. We define weaning as the period of transition in infancy between a diet based on milk feeding to one based on solid foods.

The dietary patterns of infants in the SWS were identified using principal component analysis (PCA) (16, 19). Before the PCA of the 12-month FFQ data, the foods listed on the FFQ were grouped on the basis of similarity of type of food and nutrient composition; a total of 56 food groups were entered into the PCA. The most important dietary pattern (that explained the greatest variance, 7%) at 12 months of age was characterized by a high consumption of fruit, vegetables, cooked meat and fish, and other home-prepared foods such as rice and pasta, but by low consumption of commercial baby foods. Because this pattern of feeding is consistent with weaning guidance (20), we called it the infant guidelines dietary pattern (16). An infant guidelines score was calculated for every infant using the coefficients for each food group (defined by the PCA) and the infant's reported frequency of consumption of that group. These values were summed to provide a single score for the infant that indicated their compliance with the pattern. For example, infants with infant guidelines scores in the top quarter of the distribution had a high consumption of fruit (median = 13.5 portions/wk) and vegetables (median = 15.5 portions/wk), when compared with infants who had scores in the bottom quarter (median consumption of fruit = 3.5 portions/wk; median consumption of vegetables = 5 portions/wk) (data unpublished).

Body composition assessment at 4 yr

There were 1195 singleton live births to women in the SWS between January 2000 and December 2002. Of these, 782 children were followed up at the age of 4 yr (January 2004 to January 2007), and invited to attend Southampton General Hospital for an assessment of body composition by DXA. A total of 569 children (73%) attended a clinic for the DXA scan. The child's height (using a portable stadiometer, Leicester height measurer) and weight in underwear (using calibrated digital scales; Seca Ltd., Hamburg, Germany) were measured. A list of weights for standard items of clothing was available to adjust the weight for those children who were not willing to undress. Body composition at 4 yr was assessed using a Hologic 4500 Discovery W instrument (Hologic Inc., Bedford, MA), which has a fan beam design. Total and proportionate bone, fat, and fat-free (lean) mass were derived from a whole-body scan, using pediatric software (version 12.7.3). The total x-ray dose for the whole-body scans was 4.7 μ Sv.

A total of 539 children (69%) had complete whole-body DXA measurements at 4 yr. Because fat mass and lean mass are dependent on height, height-adjusted indices were calculated (21). We used height raised to the power of 2 to calculate fat mass index [fat mass (kilograms)/height (meters)²], and height raised to the power of 2.5 to calculate lean mass index [lean mass (kilograms)/height (meters)^{2.5}]. Regression of these indices against height at 4 yr confirmed that they were not associated with height ($r = -0.04$; $P = 0.42$ for fat mass index; $r = 0.02$; $P = 0.66$ for lean mass index). Three children did not have measurements of height at 4 yr and were excluded from the analyses. Our analyses are based on 536 children (69%) who had complete body composition measurements at 4 yr.

TABLE 1. Characteristics of the SWS mothers and children

	Children with DXA measurements at 4 yr (n = 536)			Children without DXA measurements (n = 659)		
	n ^a	Mean ^b	SD	n ^a	Mean ^b	SD
Mothers						
Height (cm)	532	163.5	6.6	658	162.6	6.3
Age (yr) ^c	536	30.2	3.7	659	29.6	3.9
BMI before pregnancy (kg/m ²)	531	24.2 (median)	22.1–27.5 (IQR)	656	23.9 (median)	21.7–27.1 (IQR)
Educational attainment						
Lower than A-levels ^d	203	37.9%		324	49.2%	
A-levels or higher	333	62.2%		334	50.8%	
Smoked in late pregnancy						
No	452	87.8%		492	78.7%	
Yes	63	12.2%		133	21.3%	
Infants						
Birth weight (g)						
Boys	277	3538	515	336	3444	616
Girls	251	3396	564	318	3292	617
Age at introduction of solid foods						
Up to 3 months	65	12.1%		84	13.6%	
Up to 4 months	344	64.3%		386	62.3%	
Up to 5 months	112	20.9%		140	22.6%	
>5 months	14	2.6%		10	1.6%	
Duration of breastfeeding						
Never breastfed	67	12.5%		159	26.0%	
<1 month	111	20.8%		117	19.2%	
1–3 months	99	18.5%		119	19.5%	
4–6 months	107	20.0%		71	11.6%	
7–11 months	80	15.0%		87	14.2%	
≥12 months	71	13.3%		58	9.5%	

^a Includes some missing values.^b Mean unless otherwise noted.^c At birth of child.^d Advanced Level General Certificate of Education exams taken at age 18 yr.

Statistical analysis

Statistical analysis was performed in Stata 10.1 (StataCorp, College Station, TX). Continuous outcome variables were transformed to normality where necessary. Continuous variables were compared between two groups using *t* tests, and associations between two categorical variables were assessed using χ^2 tests. Pearson's correlation coefficients were used to assess association between two continuous variables, and multivariate analysis was performed using linear regression. Summary statistics of skewed variables are given as medians and interquartile ranges (IQR). We examined univariate associations between infant feeding variables and measures of body composition at 4 yr, and we also considered these associations after taking account of a number of confounding influences: maternal age, BMI, height, education, social class, smoking in late pregnancy, infant birth weight, and age of introduction of solid foods. The pattern scores were divided into quartiles for presentation purposes (see Table 4 and Fig. 1).

Results

Characteristics of study population

Characteristics of the 536 children and their mothers are shown in Table 1. Median duration of breastfeeding was 15.0 wk (IQR 2.0–32.4 wk), and solids were introduced at a median age of 17.4 wk (IQR 15.0–17.4 wk). The birth weights of boys were higher than those of the girls ($P = 0.003$), and boys were intro-

duced to solid foods slightly earlier (16.5 vs. 17.1 wk, $P = 0.02$). Duration of breastfeeding and the maternal characteristics shown in Table 1 did not differ between the boys and girls. When compared with mothers of children who were born between January 2000 and December 2002 but who did not have a DXA scan (Table 1), the mothers of the children studied were of similar BMI but tended to be older ($P = 0.003$) and taller ($P = 0.02$), to have a higher level of educational attainment ($P < 0.001$), to breast-feed for longer ($P < 0.001$), and to be less likely to smoke in late pregnancy ($P < 0.001$). There was no difference in the age at introduction of solid foods between the children with and without DXA scans.

Table 2 shows the anthropometric characteristics of the children who had DXA measurements when they were 4 yr old. According to the International Obesity Task Force categorization of BMI (22), 84% of the children were of normal BMI at 4 yr, 13% were overweight, and 3% were obese. There was a tendency for the boys to be slightly taller ($P = 0.062$) than the girls, but weight and BMI did not differ ($P = 0.25$ and 0.75 , respectively). Boys had a higher lean mass and lean mass index compared with the girls (both $P < 0.001$), but a lower fat mass and fat mass index (both $P < 0.001$). Body composition measurements were therefore adjusted for sex before subsequent analyses.

TABLE 2. Anthropometric characteristics of the children studied at 4 yr

	Boys (n = 283)		Girls (n = 253)	
	Mean	95% CI	Mean	95% CI
Height (cm)	104.2	103.8–104.6	103.5	103.0–104.1
Weight (kg)	17.6	17.3–17.8	17.4	17.1–17.7
BMI (kg/m ²) ^a	16.1	16.0–16.3	16.1	15.9–16.3
Lean mass (kg)	12.9	12.8–13.1	11.9	11.7–12.1
Lean mass index (kg/m ^{2.5}) ^b	12.2	12.1–12.3	11.4	11.3–11.5
Fat mass (kg) ^a	4.3	4.2–4.4	5.0	4.8–5.1
Fat mass index (kg/m ²) ^{a,b}	4.0	3.9–4.1	4.6	4.5–4.8

CI, Confidence interval.

^a Geometric means.^b Fat mass index and lean mass index calculated to be independent of height at 4 yr.

Relationship between breastfeeding duration and body composition

The associations between the duration of breastfeeding and measures of body composition at 4 yr are shown in Table 3. BMI and lean mass did not vary in relation to the duration of breastfeeding, although after adjusting for the influence of potential confounding factors (maternal age, BMI, height, education, social class, smoking in late pregnancy, infant birth weight, and age of introduction of solid foods), there was a tendency for the lean mass index to be higher among the children who were breastfed for longer. There were graded inverse associations between duration of breastfeeding and fat mass and fat mass index, such that infants who were breastfed for longer had a lower fat mass at 4 yr. These associations were still evident after taking account of potential confounding factors. Because breastfeeding may be more strongly related to overweight than to mean BMI (6), we also considered the 87 children defined as overweight or obese according to the International Obesity Task Force cutoffs (22). Breastfeeding duration was shorter among these children [median duration 8.7 wk (IQR 0.7–23.7 wk)] in the overweight or obese group compared with the remaining 449 children [median duration 17.4 wk (IQR 2.2–34.8 wk); $P = 0.031$].

Relationship between weaning diet and body composition

There was a weak inverse association between fat mass at 4 yr and age at introduction of solid foods ($P = 0.034$), but this association was not seen after adjustment for confounding factors. BMI, fat mass index, lean mass, and lean mass index were not related to age at introduction of solid foods (data not shown). Table 4 shows the associations between infant guidelines dietary pattern scores at 12 months and measures of body composition at 4 yr. There were no associations between infant guidelines scores and BMI, fat mass, or fat mass index at 4 yr, but lean mass and lean mass index were positively associated with the infant guidelines score, such that infants fed in accordance with weaning recommendations who were given a diet based on fruit, vegetables, cooked meat and fish, and other home-prepared foods had a higher lean mass at 4 yr. This association was not changed by adjustment for confounding factors.

Combined influences of breastfeeding and the weaning diet on body composition

Because infants who were fed in accordance with weaning guidance were more likely to have been breastfed for longer (correlation between duration of breastfeeding and infant guidelines scores at 12 months $r = 0.16$; $P < 0.001$), we used a combined model that included both infant feeding variables together with the confounding factors (maternal age, BMI, height, education, social class, smoking in late pregnancy, infant birth weight, and age of introduction of solid foods) to examine their independent influences on body composition at 4 yr. The relationships between breastfeeding duration and both fat mass and fat mass index at 4 yr were little changed by taking account of infant guidelines scores at 12 months (both $P < 0.01$). Similarly, taking account of breastfeeding duration had little effect on the associations between infant guidelines score and lean mass or lean mass index (both $P < 0.02$). Figure 1 shows fat mass, lean mass, and the derived indices (adjusted for the effects of confounding influences) according to breastfeeding duration in the first year and infant guidelines score at 12 months. The full models explained 10.1% of the variance

TABLE 3. Associations between duration of breastfeeding in infancy and body composition at 4 yr^a

Duration of breastfeeding	Mean (95% CI)				
	BMI (kg/m ²) ^b	Lean mass (kg)	Lean mass index (kg/m ^{2.5})	Fat mass (kg) ^b	Fat mass index (kg/m ²) ^b
Never breastfed	16.4 (16.1–16.8)	12.4 (12.0–12.9)	11.8 (11.5–12.0)	5.0 (4.7–5.3)	4.6 (4.4–4.9)
<1 month	16.2 (15.9–16.5)	12.4 (12.2–12.7)	11.8 (11.7–12.0)	4.7 (4.5–4.9)	4.4 (4.2–4.6)
1–3 months	16.2 (15.9–16.4)	12.4 (12.1–12.7)	11.8 (11.7–12.0)	4.7 (4.5–4.9)	4.3 (4.2–4.5)
4–6 months	15.8 (15.5–16.0)	12.2 (11.9–12.5)	11.8 (11.6–11.9)	4.3 (4.2–4.5)	4.1 (3.9–4.2)
7–11 months	16.1 (15.8–16.4)	12.7 (12.4–13.1)	11.9 (11.7–12.1)	4.6 (4.3–4.8)	4.2 (4.0–4.4)
12 or more months	16.1 (15.8–16.3)	12.6 (12.2–12.9)	11.9 (11.8–12.1)	4.5 (4.3–4.7)	4.2 (4.0–4.4)
P for trend ^c	0.059	0.383	0.213	0.002	0.001
P for trend (adjusted) ^{c,d}	0.171	0.961	0.041	0.004	0.015

^a All values were adjusted for sex.^b Geometric means.^c From linear regression analysis.^d Adjusted for maternal age, BMI, height, education, social class, smoking in late pregnancy, infant birth weight, and age of introduction of solid foods.

TABLE 4. Associations between infant guidelines dietary pattern scores at 12 months and body composition at 4 yr^a

Infant guidelines score	Mean (95% CI)				
	BMI (kg/m ²) ^b	Lean mass (kg)	Lean mass index (kg/m ^{2.5})	Fat mass (kg) ^b	Fat mass index (kg/m ²) ^b
<−0.68	15.9 (15.6–16.1)	12.0 (11.7–12.4)	11.7 (11.5–11.9)	4.5 (4.3–4.7)	4.3 (4.1–4.4)
−0.68–0	16.1 (15.8–16.3)	12.3 (12.1–12.6)	11.8 (11.6–11.9)	4.7 (4.5–4.9)	4.3 (4.2–4.5)
0–0.68	16.2 (16.0–16.5)	12.7 (12.4–12.9)	11.9 (11.8–12.0)	4.7 (4.5–4.9)	4.3 (4.2–4.5)
>0.68	16.1 (15.8–16.3)	12.6 (12.3–12.9)	11.9 (11.8–12.1)	4.5 (4.3–4.6)	4.1 (4.0–4.3)
<i>P</i> for trend ^c	0.205	0.001	0.011	0.609	0.166
<i>P</i> for trend (adjusted) ^{c,d}	0.102	0.003	0.004	0.781	0.488

^a All values were adjusted for sex.^b Geometric means.^c From linear regression analysis.^d Adjusted for maternal age, BMI, height, education, social class, smoking in late pregnancy, infant birth weight, and age of introduction of solid foods.

in fat mass (fat mass index, 6.7%) and 21.3% of the variance in lean mass (lean mass index, 5.5%).

Discussion

We have shown that variations in infant feeding, both in milk feeding and in the quality of the weaning diet, are associated with differences in body composition determined using DXA at the age of 4 yr. Longer duration of breastfeeding was strongly associated with a lower fat mass. Independently of the duration of breastfeeding, infants fed a diet based on fruit, vegetables, and home-prepared foods during weaning had a higher lean mass at 4 yr. These effects of breastfeeding and the weaning diet were independent of child's height at 4 yr and remained after taking

account of a range of confounding influences. An effect of the weaning diet on later body composition assessed by DXA has not been described before. There were no associations between variations in infant diet and mean BMI at 4 yr, although overweight and obese children tended to be breastfed for a shorter period.

Strengths and weaknesses

The children we studied were born to women in the SWS, a general population sample of women and their children living in Southampton, from a wide range of sociodemographic backgrounds (18). The children were visited by trained research nurses at 6 and 12 months of age, when contemporary information on milk feeding and diet was obtained. This should minimize any effect of recall bias that may influence retrospective reports of infant feeding if determined at later ages. Diet was assessed

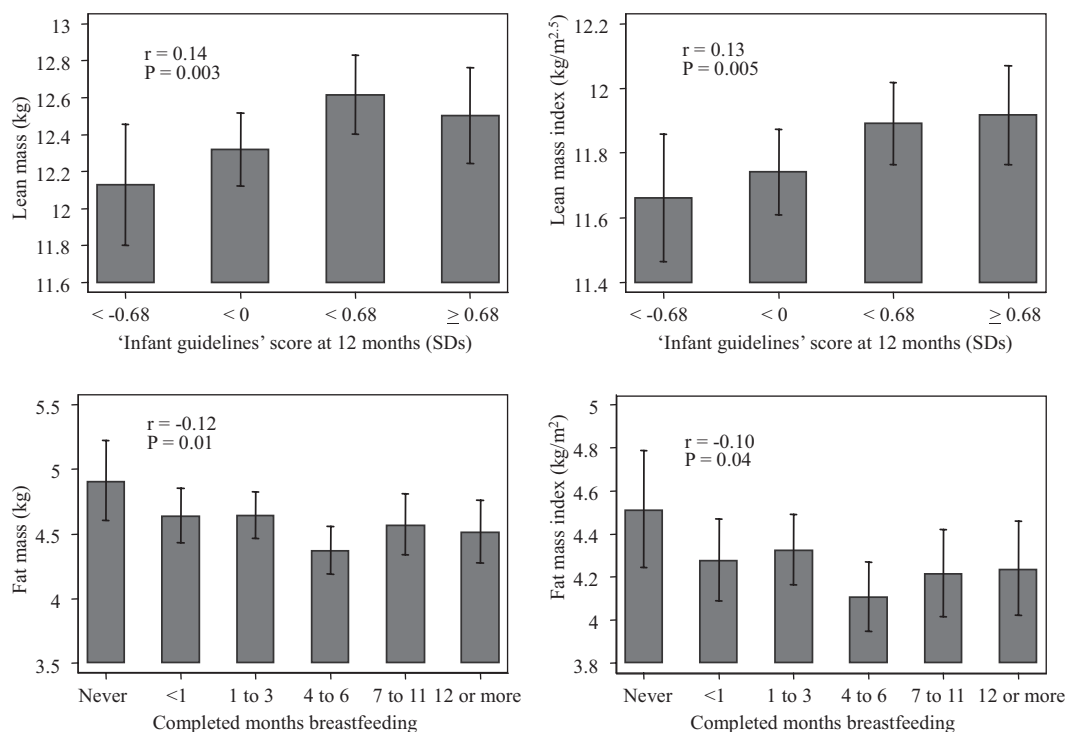


FIG. 1. Body composition at 4 yr according to duration of breastfeeding in infancy and infant guidelines score at 12 months of age. All values were adjusted for maternal age, BMI, height, education, social class, smoking in late pregnancy, infant birth weight, and age of introduction of solid foods. Lean mass and lean mass index were also adjusted for breastfeeding duration, and fat mass and fat mass index were also adjusted for infant guidelines score at 12 months.

using FFQs that were administered by trained research nurses. Although there is concern that FFQs can be prone to measurement error (23), they have been shown to identify similar patterns of diet as other dietary methods, and dietary pattern scores determined using different dietary methods are highly correlated (16, 24).

A strength of our study is that we used DXA to assess body composition, which provided direct measures of fat mass and lean mass, and we also considered fat and lean mass indices that were independent of the child's height. Using BMI as a surrogate measure of adiposity, we saw no relationships with the duration of breastfeeding, whereas there were strong associations with DXA-assessed fat mass at 4 yr. The lack of association with BMI is consistent with the findings of the PROBIT trial (7) and indicates that BMI may be of limited use as a measure of adiposity in early childhood (25). A weakness of our study is that we did not approach all the children in the SWS cohort and that 31% of the children approached did not have a DXA scan. Although the mothers of the children studied tended to have higher levels of educational attainment and to breastfeed for longer than other mothers in the SWS, the children studied came from a wide range of backgrounds. Unless the associations were different in the remainder of the cohort, it is unlikely that selection bias could explain the relationships between infant feeding and body composition that we observed. When we took account of the effects of a number of confounding influences, most notably maternal BMI, which has been shown to be associated with the offspring's adiposity (14), we found that the adjustments made little difference to the associations with body composition (Tables 3 and 4).

Breastfeeding and body composition in childhood

We found a graded association between breastfeeding duration and DXA-assessed fat mass, which was little changed after taking account of a range of maternal factors, infant birth weight, age of introduction of solid foods, and the infant guidelines pattern score. In contrast, Burdette *et al.* (13) found no significant difference in fat mass among 313 children aged 5 yr in relation to breastfeeding duration, although there was a tendency for fat mass to be lower among the children who were breastfed. These differing findings may be due to differences in statistical power but could also be explained by differences in the assessment of breastfeeding, which in their study, was reported when the children were aged 3 yr (13). Our findings of lower DXA-assessed fat mass in relation to longer duration of breastfeeding are comparable to those of Toschke *et al.* (10). However, our conclusions differ. Although we cannot exclude the possibility that longer duration of breastfeeding is acting as a marker of less obesogenic family characteristics (10, 11), we do not think the associations we observed are largely explained by confounding influences.

Weaning diet and body composition in childhood

We found that infants who were fed according to infant feeding recommendations and who were provided with a diet based on fruit, vegetables, meat and fish, and other home-prepared foods such as rice and pasta during weaning had a higher lean mass at 4 yr. These associations were not explained by maternal

height, BMI, education, or smoking status in pregnancy and were independent of infant birth weight, the age of introduction of solid foods, and the height of the child at 4 yr. Although the choice to breastfeed and the duration of breastfeeding are socially patterned, and the diets of breastfed and formula-fed infants may differ (17), the association between the infant guidelines dietary pattern score and later body composition we observed was independent of duration of breastfeeding. We did not find any associations between variation in the weaning diet and adiposity at 4 yr. We have previously reported greater gains in skinfold thickness between 6 and 12 months among infants fed according to weaning guidance at 6 months of age, although gain in skinfold thickness was not associated with their dietary pattern at 12 months (26). One possible explanation for the association seen at 6 months is that there are small short-term differences in adiposity among infants with different early weaning diets that do not persist beyond infancy. This highlights the need to examine associations between infant diet and body composition in children at older ages (26).

The mechanisms linking variations in the weaning diet to a greater lean mass in childhood are unknown, and we do not know whether individual compartments of lean mass are affected equally. One possibility is that the quality of the infant diet is indicative of the quality of the diet provided in the following years and that a diet characterized by fruit, vegetables, and home-prepared foods provided throughout early childhood allows greater growth in lean mass. This might be expected because tracking of dietary patterns in infancy and in early childhood has been described (16, 27), and we would predict that the nature of the diet provided to SWS infants at 12 months would be similar to their childhood diet. A second possibility is that families that provide an infant diet that conforms to recommendations have other characteristics that could affect growth and development in early childhood. Families vary in their obesogenic characteristics, notably in levels of dietary intake and physical activity (28). It is possible that higher infant guidelines scores are indicative of other behavioral differences (29) including higher levels of physical activity in childhood and that these differences have effects on growth and development.

In conclusion, our data show that adherence to current recommendations to breastfeed and to provide a weaning diet based on fruit, vegetables, and home-prepared foods is associated with a higher lean mass and a lower fat mass at 4 yr of age. Although with so few studies of DXA-assessed body composition in childhood to date so that the long-term consequences of the differences described at 4 yr may be uncertain, these observational findings provide some support for existing infant feeding guidance.

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